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ABSTRACT

This paper examines the energy problem. Specific topics discussed include the recent history of oil and gas consumption in the United States, conservation, coal, solar energy, and nuclear energy. While solutions to the energy problem differ, there is an urgent need for broad, public debate. Ultimately, the decisions made regarding energy will be political, but no option can survive without long term public support. The public must be apprised of the advantages and disadvantages of the many hard choices to be made and along with special interest groups be ready to compromise in numerous ways in order to achieve some measure of consensus. In addition, the benefits and risks of different energy choices should not be assessed in isolation from their international setting. The ramifications of energy-related decisions vividly demonstrate the interdependence of nations. A decision to burn more coal in Great Britain or the United States directly affects the amount of acid rain falling on Northern Europe and Canada. Fallout from a nuclear accident in Sweden would be scattered over Denmark while the level of solar energy research in industrialized countries will directly affect the likelihood of economic survival for sun rich, resource-poor developing countries. (Author/RM)

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CAVEAT EMPTOR: CALCULATING ALL THE COSTS OF ENERGY

BACKGROUND

At one time the eternal verities were limited to death and taxes. To that old bromide we can now add expensive energy. Gone are the days when cheap electricity, gasoline and home heating fuels were considered part of an American citizen's inalienable rights. Gone too but with less certainty is the not-groundless conviction that the energy problem is solely the result of Machiavellian collusion among the oil companies with government in order to reap "obscene profits."

Not gone but which should should have disappeared is the notion that lying just around the corner is a quick technological fix which when found will end this unpleasant interval. Not only are there direct problems stemming from the availability and cost of energy resources themselves but also lurking just underneath the surface of many other critical problems -- agricultural productivity, desertification, environmental pollution, overpopulation, large-scale unemployment, decreasing economic productivity, and threats to national security -- are the indirect effects of rising prices and diminishing supplies of the

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energy resources needed to ameliorate them. These complex ramifications through many aspects of domestic, international and global functioning, augur that the energy problem will persist for a long time. One of the reasons the problem is destined to remain for the foreseeable future is that there is no clear cut answer on how to proceed to resolve near-term problems or the more long-term transition from fossil fuels to renewable sources of energy. Every choice will have its costs -- economic, social and political -- some less apparent than others.

Consequently it is important to understand just what the energy problem is, how it has come about, what accounts for the often passionate yet legitimate differences of opinions among experts and the general public about which energy policies should be enacted and what actions might lessen the seeming intractability of the problem or, more accurately, problems. The energy problem is many problems and the options for solving each aspect of it while pleasing one are likely to enrage or at least discomfit others.

Those who believe that strengthening national security is the highest priority will recommend different ways of dealing with energy problems than will those who are predominantly concerned with the protection of the environment. Those who believe that the country must be geared to producing the largest number of goods and services will differ in their recommendations from those who believe that a major energy goal should be to conserve resources for future generations. Each of these beliefs or values contributes to the definition of the problem and the

options available to achieve specific goals. Where at one time economic costs and profits were the only significant factors used to determine energy options, now increasingly an informed public aided by recent legislation (National Environmental Protection Act (NEPA) and the Freedom of Information Act) insists that social costs (risks) and profits (benefits) be included in the decision-making processes. Each option then, reflects a system of values and an image of what society should be.

Slogans abound: small is beautiful; split wood not atoms; coal is the answer; the greatest nuclear risk is doing without it; decentralize energy. Americans are still in a state of shock about the end of cheap energy. Indeed, many do not yet believe it is real; as recently as 1977 some 50% of the public did not know that we imported oil. Because the future promises to be radically different from the recent past, it is taking us a long time to assimilate what has happened.

RECENT HISTORY OF OIL AND GAS CONSUMPTION IN THE UNITED STATES

Throughout the middle years of this century several Cassandras predicted the end of fossil fuel. Being out of tune with the optimism of an ever expanding economy which promised unending prosperity they received little attention. Oil and gas were cheap and readily available. Besides, the atom had been harnessed in the 1940s and would provide electricity "too cheap to meter" -- a promise which even if apochryphal, conveys the certainty with which nuclear technology was launched. American technology which had proven itself gloriously in World War II

could be counted on to provide for the future.

Energy policy was not an issue; the country was booming. Unravaged by war, possessed of high technological competence, a work force that was mobile both geographically and socially, united in its belief in hard work, the United States prospered dramatically between 1950 and 1970. The economic growth was unprecendented -- average real income in constant dollars rose from $5600 to $12,000 -- and the majority of the population became comfortably middle class.[1] Highways proliferated, suburbs mushroomed, and the automobile became the backbone of the economy and the symbol of individual success. American women were said to deliver first obstetrically and after that, indefinitely -- by car.

With the exception of the period of the Great Depression each generation of Americans had improved its lot over that of its parents. As American technology dominated world markets and incomes continued to rise, there was little reason to believe that this Golden Age would not continue. A national mood of rising expectations gave way to that of rising entitlements and what had been the hallmark of affluence before the war -- home ownership, an automobile, summer vacations and college educations -- came to be expected by those recently arrived in the middle class. No small amount of the prodigious growth stemmed from availability of cheap seemingly unlimited supplies of oil and gas which were being consumed at an increasing rate of 3.4% each year (4.5% between 1965-73).

Throughout the post-war decades, oil imports began to rise

steeply as the real price continued to fall. The Organization of Petroleum Exporting Countries (OPEC) which had been organized in 1960 with little international attention was for its first ten years unable to change the downward direction of the pre-1947 price of $2.17 per barrel to the 1969 low of a little more than $1.00 per barrel.[2] By 1969, the U.S. was consuming six times as much energy per capita as the world average. Demand continued to grow but domestic oil production had reached its peak in 1970 and began to decline; it also could no longer compete with cheaper imports. By 1973, the U.S. was importing 35% of its oil and the price had quadrupled.

The first Arab oil embargo In 1973 produced panic and a blinding, if brief, flash of insight. Informed citizens and government officials were aware that the party was over -- cheap, reliable oil was soon to be a relic of the past. More importantly they realized that in a rush to economic growth, a much needed energy policy (or policies) had not been formulated.

Without a more energy independent economy, the U.S. had become vulnerable to supply interruptions and price manipulations. The country's non-oil producing allies were even more critically affected. Japan was virtually 100% dependent on imported oil, France 75% and Germany 60%. The implications were inescapable. The Arabs, dissatisfied with American aid policy to Israel, had turned oil into a potent political weapon and would threaten further disruptions. In addition, the allied nations became aware of their interdependence; an oil shortage in one strained the economic and political relations of all of them.

The majority of the American public, however, was still convinced that the real problems had to do with pricing and that once the producers could exploit the consumers by raising the prices of domestic natural gas and oil, the problem would go away. Accordingly, there was little sustained impetus to forge a comprehensive energy plan and reduce oil imports. Rather, imports continued to rise. Between 1972 and 1978 imports almost doubled from 4.7 million barrels per day (mbd) to 8.4 mbd or more tellingly, from 29% to 47% of all oil consumption.[3] The annual expenditure for foreign oil was approximately $40 to $50 billion. It was not until the overthrow of the Shah in 1978 that a once indifferent public was truly shaken. Between 1978 and 1979 alone, the world price of oil doubled (from $13-$30) and the dollar declined sharply. Even all-powerful American technology which had been counted on to deliver the country from a precarious oil supply to safe, clean and inexpensive nuclear power, seemed to falter when the event at Three Mile Island in March of 1979 further shook American complacency about the ease of an energy transition.

During a period of one hundred years, the country had moved fairly smoothly from wood to coal to oil and natural gas each transition having been, as a general rule, to a cleaner, cheaper and more abundant source than the energy resource it replaced. The next transition began to appear fraught with uncertainty -- social, political and economic -- and the American public and government were ill-prepared to deal with it.

At this point the American people have to consider a number

of options, four of which will be considered here. Conservation, coal, solar (including wood, wind, tidal power, ocean thermal conversion, photovoltaic cells, etc) and nuclear are the most immediate choices to be developed during the transition away from fossil fuels to renewable energy resources. (Nuclear fusion which uses hydrogen isotopes and promises virtually limitless sources of energy is still a 'noble dream.') Some of the advantages and disadvantages of these options are well known. More subtle ones such as the environmental damage produced by something as seemingly benign as woodburning (pollution and soil degradation from phenol-containing ash) will be discussed here.

CONSERVATION

Decidely less exciting than the technology of nuclear fusion, conservation which began with the need to reduce dependence on imported oil, got off to a grudgingly slow start. In 1973, after the OPEC oil embargo, had the government mounted a concerted conservation effort, oil imports could have begun to drop. Instead by 1979 imports almost doubled while prices tripled! The apparent refusal of American government and industry to reduce the country's oil imports, triggered an underlying resentment among its allies who interpreted this lack of response as arrogance and indifference.

Not until oil prices doubled once more did the abrupt change begin. Imports started to drop and energy conservation took hold. By the winter of 1980 the demand for home heating oil decreased by 13% over the previous year even though the winter

had been three degrees colder. Price decontrol contributed to the 20% drop of imports from their highest point; so did efficiency, lower thermostats and insulation. Just when conservation had taken firm enough hold so that OPEC was being paid $50 million less every day, the Reagan administration made it clear that conservation had little place in its policy.[4] Cutting back on loans, grants and other incentives for home insulation, indecisive about maintaining the 55 mph speed limit and drastically cutting funds for public education the administration has severely impeded the momentum.

At the same time declining world demand and internal disagreements within OPEC have produced a temporary glut of oil and a cutback in prices. Oil (as well as gas and coal), remain finite resources. Whether oil is exhausted within fifty or one hundred years is less significant than the fact of its finiteness. Oil and natural gas constitute 70% of U.S. energy consumption. Even with a drop in oil prices other resources once considered uneconomic are being pursued. Each has noteworthy advantages and, consequently, strong advocates, while none of them is without drawbacks -- social, political, environmental, health or economic. The antagonists are equally committed.

Even conservation, the most panglossian of options has begun to reveal unanticipated risks.[5]

> "As we insulate our houses better to save energy we reduce the inflow of fresh air. Since at least 75% of most people's lives are spent indoors, indoor pollution can become a serious problem. Plant fungicides, dry cleaning fluids, carbon monoxide, cadmium from cigarette smoke, etc., may be at much higher concentrations in our better insulated houses of tomorrow than they are today. Particularly vulnerable

> are the children who grow up in these homes. They would have more years of exposure to these pollutants than we did and their breathing rate per unit of body weight is much greater than an adult's. The concentration of many of these heavier-than-air pollutants is greater at a child's height than at an adult's. It is possible that a well intended act of energy conservation could result in a public health hazard, only to be perceived years later."

If that is not sobering enough, a recent study has demonstrated that concentration of natural background radiation products will increase to dangerous levels as the ionized particles which in the past circulated freely between the inside and the outside of the house would be trapped in well insulated homes.[6] The level of radiation could exceed those acceptable in the area of a nuclear power plant. This is not to suggest that home insulation and the search for the resolution of its problems should not continue but rather that even the most benign energy option is likely to have a hidden cost and that the promise of a risk-free choice is misleading.

COAL

Beginning in the 1970s, Congress has tried to spur the use of coal which it had identified as the transition fuel. The United States with 31% of the world's reserves has been dubbed the "Saudi Arabia of coal." This supply is sufficient to provide between half and two thirds of the world's additional energy needs for the next twenty years. To do so, however, coal production would have to increase nearly 300%, an awesome task when the current deteriorated state of trains, railroad tracks and harbors are considered. Coal has been promoted as the

alternative to nuclear power and as the basis of the synthetic fuel that would be cost competitive with OPEC oil by 1990. The World Coal (WOCOL) Study directed by an M.I.T. scientist has identified coal as the nation's "bridge to the future."[7] However, a growing body of evidence shows that coal burning causes serious environmental and health problems which have yet to be adequately explored. Even promoters admit that there is probably a relationship between coal burning and at least two major environmental problems. One is acid rain and the other is the increase of carbon dioxide in the atmosphere. When coal is burned, it releases nitrogen oxides and sulfur dioxides that combine with the moisture in the atmosphere making the rainfall acidic. According to a recent study acid rain is "an insidious but deadly pollution resulting from industrial combustion. As well as killing fish populations and aquatic vegetation, it threatens forests, crops and soils; erodes building and automobile surfaces; and may be a danger to human health."[8] This and several other reports suggest that the damage may also be irreversible.

Carbon dioxide that is also produced by burning coal causes the earth's surface to warm in such a way that some scientists believe the Polar ice cap could melt, coastal cities be inundated and once fertile agricultural regions submerged. Until recently most of the notions about carbon dioxide have been speculative. However a study by seven scientists from the National Aeronautics and Space Administration (NASA) reveals that on a global basis carbon dioxide has already been warming the earth for a century

and predicts that it will produce "unprecedented" warming in the next century.[9] This could result in the "creation of drought-prone regions in North America and Central Asia as part of a shifting of climatic zones (and) erosion of the West Antarctic ice sheet with a consequent worldwide rise in sea level." Definitive results are not as yet available, but this kind of warning from other than environmentalists suggests that those who would want to slow the development of solar because it is too expensive or of nuclear because it is too hazardous will have to include these findings in their decisions.

In time technology will most likely be developed to cope with the sulfur dioxide and nitrogen oxides emitted during the combustion of fossil fuels -- many devices are already in place but too expensive to use routinely. However, the warming effect of burning more fossil fuels is not amenable to technological intervention regardless of the money expended.

There are other social costs of coal mining. For example, much of the future coal will be strip mined, disrupting large tracts of land and forcing changes on the society and the economy of the people living near the mines. Even more traumatic to residents would be "the cultural clash when large numbers of transient mine workers move into rural communities." The combination of the damage to the soil in strip mining, the cost of reclamation, the upheaval of lives of people living near the mines, and the larger environmental damage have led a committee at the National Academy of Sciences to predict that "coal may eventually be priced out of the fuel mix when its price includes

the social costs of mining and combustion."[10]

SOLAR ENERGY

For many solar holds the greatest promise for long-term future supplies of energy. Although if the Reagan administration plans to cut the solar budget by 66% are carried out, the likelihood of any significant growth in solar energy production will dim markedly.

Estimates of what solar energy will actually be able to contribute by the year 2000 vary dramatically from 5% to approximately 40%. If we assume optimistically that with major backing from government solar could contribute as much as 20% to the country's energy supply by the year 2000, the public will still feel betrayed. In a survey reported by Roper, 57% of the public expressed the opinion that solar would replace oil within five years; 63% predicted it would replace oil by the year 2000.[11] Whether as Roper commented this was naivete or clairvoyance, the important issue here is that the public believes solar can and will replace oil. Like the nuclear option in the 50s, solar energy is being overpromised.

The advantages of solar energy are well known. Its current problems -- high costs and insufficient research funds to develop its potential -- are also well publicized. What is less well understood are the potential consequences of global deployment. As the nuclear power industry learned to its dismay, when the number of nuclear power plant was small, there was little public concern. It was only when numerous plants began to

come on line that the anti-nuclear movement began to grow. What will happen to the support for solar energy when as a scientist has pointed out:

> "large areas of desert lands are covered with machines, valleys are flooded to provide hydroelectric facilities, and scenic coastlines are dotted with thousands of towers holding wind generators."12

In addition, it is not unlikely that "covering upwards of a million square kilometers of sunny land with solar conversion machines" will modify the climate and produce increased cloudiness and rain.

As with the other unanticipated drawbacks to energy options, they do not suggest that the research for their development should lag but rather that the public should become aware early in the process that even solar -- the best and the brightest -- will not be a panacea.

NUCLEAR ENERGY

By far the most controversial of all energy choices, nuclear energy has stimulated unprecedented hopes and unparalled fears; it remains today a bitter national controversy.

Despite the growing evidence of the damage that coal is likely to cause to the environment (including the deposition of radioactive ash) and health, as well as the likelihood of accidents from coal mining and transportation, the general public still believes that nuclear power holds greater risks.

The history of these perceptions is complex. Nuclear energy had its origins in war, destruction and secrecy; these negative antecedents have never been dissociated from nuclear power's

peaceful applications. Radiation which is invisible, without smell and penetrates skin arouses powerful fears.

The impressive safety record of the nuclear industry is lost on those who reason, "What if?" What if there is a core meltdown? What if the disposal of high-level nuclear wastes is inadequate and radiation leaks into the groundwater? What if the transportation of these wastes is so dangerous that armed guards have to protect them and the sites at which they are stored? What if terrorists can blackmail the country with stolen plutonium? What if increasing concentrations of radiation cause genetic damage? What if this highly centralized, large-scale technology increases the social control industry and government have over the lives of individuals? Will democracy be threatened? Every aspect of nuclear energy is fraught with controversy.

At present, the future of conventional nuclear energy is uncertain. Conservation and a slowdown in the economy with a resulting overcapacity in electricity generation has left the industry in shambles. Electric utilities are slowly converting to coal, no new orders have been placed for reactors in recent years, and between 1978 and 1981, thirty-five plant construction projects were canceled. Even pronuclear investors are loath to invest funds in such unpromising, risky circumstances.

But now the "What if?" question has to be reversed. What if coal proves too dangerous or solar too unwieldy? What if conservation reaches its limits and there is still insufficient energy to fuel the needs of the American economy? Or what if the

Americans slow their technological research and are unable to provide either resources or technology for energy-depleted developing nations? Nuclear, then might be reassessed by all but its staunchest opponents.

CONCLUSION

In a rush to solutions, short term decisions are being made by legislators who worry about reelection every other year; it is difficult to campaign on a promise of rising prices. Scientists trained in empirical methods often disregard qualitative factors -- human response, fears and expectations -- in their calculations. Industrialists whose career success is measured by annual profits find it difficult to implement long-range plans while the consumer hard pressed by rising prices finds it difficult to focus on global issues of rising CO_2 concentrations in the atmosphere or other environmental changes not likely to occur for one hundred years. Each group has something different to learn.

Opinions differ but there is an urgent need for broad, public debate. The secrecy which served the country well in the war-time development of nuclear energy proved disastrous when carried over into peace time. Public skepticism and distrust have been its legacy. Increasing polarization between growth and no-growth advocates or the pro- and anti-nuclear groups can, if not moderated, cripple the country as it tries to deal with the new realities. Ultimately the decisions will be political but no option can survive without long term public support. The public

then must be apprised of the advantages and disadvantages of the many hard choices to be made and along with special interest groups be ready to compromise in numerous ways in order to achieve some measure of consensus.

In addition, the benefits and risks of different energy choices should not be assessed in isolation from their international setting. The ramifications of energy-related decisions vividly demonstrate the interdependence of nations. A decision to burn more coal in Great Britain or the United States directly affects the amount of acid rain falling on Northern Europe and Canada. Fallout from a nuclear accident in Sweden would be scattered over Denmark while the level of solar energy research in industrialized countries will directly affect the likelihood of economic survival for sun-rich, resource-exhausted developing countries. All these factors must be calculated into the true costs of energy -- anything less leaves us vulnerable to traumas far greater than the first shock of the energy transition.

[1]Daniel Yankelovich New Rules: Searching for Self Fulfillment in a World Turned Upside Down (New York: Random House), 1981, p. 21.

[2]Robert Stobaugh and Daniel Yergin. Energy Future: Report of the Energy Project at the Harvard Business School. (New York: Ballatine Books), 1980, p. 25.

[3]Stobaugh and Yergin, op. cit., p. 17.

[4]The Reagan Energy Slogan. New York Times Editorial, 4/14/81.

[5]Herschel Specter, "Getting the West Out of the Oil Dilemma: An Energy Family Approach." (Washington, D.C.: Atlantic Council), p. 33.

[6]H. Hurwitz, Jr. "Effects of Ionizing Radiation" Public Comments on the Work Group Reports, Interagency Task Force on Health. Doc. 62, DHEW, June 1979.

[7]World Coal Study (WOCOL) Coal-Bridge to the Future, Vol. 1 & 2 (Cambridge, MA: Ballinger), 1980.

[8]Downwind, Environment Canada, (Ottawa, Ontario: Information Directorate). Precisely what percentage of acid rain comes from coal combustion is uncertain as it also results from the combustion of all fossil fuels, human activities and probably from the exhaust of automobiles.

[9]NASA Study, "Climate Impact of Increasing Atmospheric Carbon Dioxide" Science, Vol. 213, #4511 August 28, 1981, p. 957.

[10]Committee on Soil as a Resource in Relations to Surface Mining for Coal. Board on Mineral and Energy Resources; Commission on Natural Resources, National Research Council, Surface Mining: Soil, Coal and Society. (National Academy Press, 1981).

[11]Burns Roper, speech delivered to Atomic Industrial Forum (Washington, D.C.), November 18, 1980.

[12]J. Weingart, "Systems Aspects of Large Scale Solar Energy Conversion." (Laxenburg, Austria: International Instituted for Applied Systems Analysis). Quoted in "Solar Energy for the Next 5 Billion Years." Richard Caputo, IIASA. May 1981, pp. 81-9.